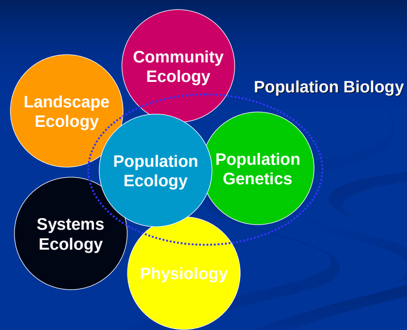
Population Ecology Relative to Other Ecological Disciplines



The term "population" is interpreted differently in various sciences:

- *In human demography* a population is a set of humans in a given area.
- *In genetics* a population is a group of interbreeding individuals of the same species, which is isolated from other groups.
- *In population ecology* a population is a group of individuals of the same species inhabiting the same area.

Populations

- A group of interbreeding, or potentially interbreeding, organisms of the same species occupying a particular space at the same time.
- Characterized by:
  - Density } Population Structure
  - Age structure
  - Grow and shrink } Population Dynamics

Defining Populations

Problems?

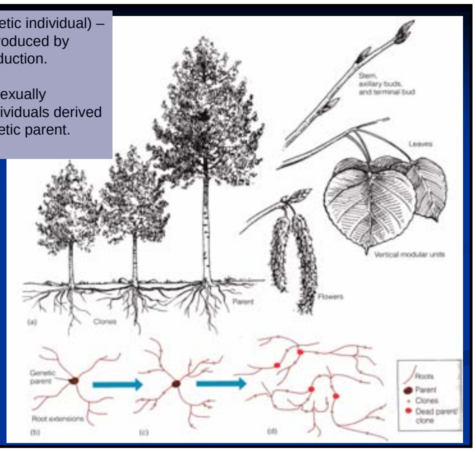
- Defining boundaries.
- Defining number of individuals present.

Aspen Trees

White-tail Deer

Genets (genetic individual) – individuals produced by sexual reproduction.

Ramets – asexually produced individuals derived from the genetic parent.



Density

The size of a population in relation to a definite unit of space.

- The measure of the number of individuals per unit area is called ***crude density***.
- Density measured in terms of the amount of area available as living space is ***ecological density***.

The Importance of Scale

People & Their Areas of Study

25 Jorge Luis Borges
24 Albert Einstein
23 Edwin Hubble
22 Vera Rubin
21 George Hale
20 Vincent van Gogh
19 Zoen
18 Wangari Maathai
17 Gideon Tjupurrula
16 Charles Darwin
15 Berhane Asfaw
14 Lucy Jones
13 Johannes Kepler
12 Nicolaus Copernicus
11 Omar Khayyam
10 Sir Isaac Newton
9 George Carruthers
8 Children
7 Wendy Johnson
6 Archimedes
5 Henry David Thoreau
4 Manuel Cortez-Martinez
3 Jawahar Gidwani
2 The Wright Brothers
1 Frank Lloyd Wright

0 Chuang-Tzu
-1 Jane Austen
-2 Florence Griffith-Joyner
-3 E. O. Wilson
-4 Frances Conley
-5 Laurie Anderson
-6 Harold Edgerton
-7 John Harrison
-8 Flossie Wong-Staal
-9 Watson & Crick
-10 Mikhail Tswett (Tsvet)
-11 Michael Faraday
-12 Werner Heisenberg
-13 Niels Bohr
-14 Marie Curie
-15 Enrico Fermi
-16 Hideki Yukawa
-17 C. N. Yang
-18 Alan Guth

Populations can be defined at various spatial scales –

- Local populations can occupy very small habitat patches like a puddle.
- A set of local populations connected by dispersing individuals is called a *metapopulation.*
- Populations can be considered at a scale of regions, islands, continents or seas.
- Even the entire species can be viewed as a population.

Populations Differ in Their Stability

- Some of them are stable for thousands of years.
- Other populations persist only because of continuous immigration from other areas.
- On small islands, populations often go extinct, but then these islands can be re-colonized.
- Finally, there are temporary populations that consist of organisms at a particular stage in their life cycle.

For example, larvae of dragonflies live in the water and form a hemipopulation.

Populations can be classified into the following groups:

1. ***Independent populations***. Can persist without any immigration, and its numbers do not depend on immigration.
2. ***Semi-dependent populations***. Can persist without any immigration, however, its numbers depend on immigration. If there is no immigration, then the abundance is much lower than in the presence of immigration
3. ***Dependent populations***. Cannot persist without immigration, however, organisms can reproduce there. Reproduction is not sufficient to sustain population numbers.
4. ***Pseudopopulation***. Do not reproduce at all. All organisms are immigrants.
5. ***Temporary populations***. In contrast to the first 4 types, these populations always become extinct after a while. Re-colonization is a rare event and thus, for some period of time the population is absent in the area. Temporary populations may reproduce however it is not sufficient.
6. ***Hemipopulations.*** These are populations that consist of individuals in specific stages. Only those species that change their environment during the life-cycle have hemipopulations.

Main axiom of population ecology: organisms in a population are *ecologically equivalent.*

Ecological equivalency means:

- Organisms undergo the same life-cycle
- Organisms in a particular stage of the life-cycle are involved in the same set of ecological processes
- The rates of these processes (or the probabilities of ecological events) are basically the same if organisms are put into the same environment (however some individual variation may be allowed).

Population Estimation

Why do we care?

- Abundance of individuals in plant and animal populations is a basic population parameter that many ecologists may be interested in knowing.
- Related to abundance, density is the number of organisms per unit area or volume.
- Although by itself abundance is not a very scientifically interesting parameter, it is an important component of population studies.
  - The size of a population will affect other biological processes such as reproduction, survival, level of inbreeding, and predator-prey dynamics.
  - On an applied level, park managers and conservation biologists may use population size as an indicator of the status of a species.
- Many different methods have been developed to estimate population size.
  - Use of any particular method depends on many factors including ecological characteristics of the species, statistical assumptions of the method and ease of implementing the method.

Population Types

- A ***closed population*** refers to a population that is not changing in size (i.e., no births or deaths, and no immigration or emigration).
- An ***open population*** refers to a population that is changing in size over the study period.

Mark-recapture Techniques

Individuals captured/marked → Resampled

- Data then used to estimate population size.
- Different methods for estimating population size

Population Type	Sampling Design	Method
Closed population	Single marking and single recapture	Lincoln/ Peterson
Closed population	Multiple markings and recaptures	Schnabel
Open population	Multiple markings and recaptures	Jolly-Seber

Assumptions

To accurately estimate N_0 with the Peterson method, these five assumptions must be met:

1. The population is closed,
2. All animals have the same chance of being caught in a sample (i.e., must be a random sample),
3. Marking animals does not effect their catchability,
4. Animals do not lose marks between the two sampling periods and marked individuals are completely mixed in the population, and
5. Sampling must be at discrete time intervals & sampling must be short relative to overall time.

Lincoln-Peterson Method (Capture-recapture/Mark-recapture)

- Simplest mark-recapture method for estimating population size.
- All animals in a single sample are given a mark or tag and returned to the environment alive (**M**).
- Later, a single sample is taken and all animals are examined for the mark.
- In this recapture sample, a total of **n** animals were captured and **R** were found to have the mark.
- If we argue that the proportion of animals in the recapture sample that had the mark (i.e., **R/n**) is the same as the proportion of animals in the population that had the mark (i.e., **M/N**) then we can set the ratios equal,

Logic behind population estimation:

$$\frac{\text{Number marked in recapture sample, (R)}}{\text{Total number in recapture sample, (n)}} = \frac{\text{Total number marked in population, (M)}}{\text{Total number estimated in population, (N)}}$$

Lincoln-Peterson Method (Capture-recapture/Mark-recapture)

- Intuitively, this relationship states that the population size is equal to the number of animals marked divided by the estimate of the proportion that are marked.
- This Equation tends to overestimate the Population Estimate.
- To account for this overestimation, Bailey's modification is used :

$$N_B = \frac{M\,(n+1)}{R+1}$$

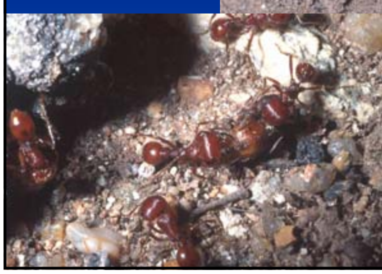
Example

- Assume that you captured 100 animals in the first sample,
- marked them all, and returned them all alive to the environment.
- A few days later, you come back and captured 40 fish,
- of which 10 had the mark you applied to the fish in the first sample.

$$N = \frac{(100)(40)}{10} = 400$$

$$N_B = \frac{(100)(40+1)}{10+1} = 373$$

Study Species



Pogonomyrmex barbatus

LD50 values in mice for toxins found in Hymenoptera

Family	Species	Common Name	LD50 (mg/kg)	Reference
Apidae	*Apis mellifera*	honey bee	2.8	Schmidt 1990
Mutillidae	*Dasymutilla klugii*	velvet ant	71	Schmidt et al. 1980
Vespidae	*Polistes canadensis*	paper wasp	2.4	Schmidt 1990
Vespidae	*Vespula squamosa*	yellowjacket	3.5	Schmidt et al. 1980
Formicidae	*Pogonomyrmex* spp.	harvester ants	0.66	Schmidt 1990
Formicidae	*P. maricopa*	harvester ant	0.12	Schmidt et al. 1989

Fun with Liquid Paper

Potential Problems

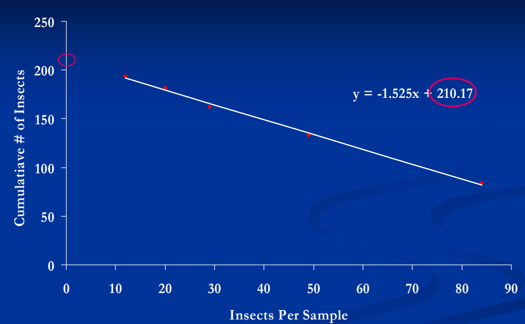
1. Mixing time - one of the parameters of this method is letting the marked individuals mix back into the population
   - if we do not give them enough time to mix, this may increase the odds of catching a marked individual which then causes us to underestimate the population size
   - if we allow them to mix for to long risk marked individuals may leave the area (emigrate) which could decrease our odds of catching marked individuals and cause an overestimate of the population size
2. Births and Deaths - we are not considering how many ants are born or die during the time we do our experiment
3. No immigration or emigration – assumption is that the population is closed with none of the ants leaving the area and no new ants entering the area
4. We are assuming animals keep their marks and we are assuming marks don't hinder animal and keep it from going about its normal way of life.

Removal Sampling

- If the assumptions of the mark-recapture method cannot be met, replacement or removal methods can be used.
- Used especially with arthropods and rodents,
- Sampling entails permanent removal of the study organism.

Hayne Method

- Involves taking a series of samples from a population.
- Each sample involves the same amount of effort.
- Number of individuals from each collection is plotted against the cumulative OR previous number captured.
- Population estimation then extrapolated.



Tenebrio molitor